New Eye on Nature: The Real Constant Is Eternal Turmoil

The 'balance' theory may be more poetry than science.

By WILLIAM K. STEVENS

IN a revision that has far-reaching implications for the way humans see the natural world and their role in it, many scientists are forsaking one of the most deeply embedded concepts of ecology: the balance of nature.

Ecologists have traditionally operated on the assumption that the normal condition of nature is a state of equilibrium, in which organisms compete and coexist in an ecological system whose workings are essentially stable. Predators and prey — moose and wolves or cheetahs and gazelles, for instance — are supposed to remain in essentially static balance. Anchovies and salmon reach a maximum population that can be sustained by their oceanic environment and remain at that level. A forest grows to a beautiful, mature climax stage that becomes its naturally permanent condition.

This concept of natural equilibrium long ruled ecological research and governed the management of such natural resources as forests and fisheries. It led to the doctrine, popular among conservationists, that nature knows best and that human intervention in it is bad by definition.

Now an accumulation of evidence has gradually led many ecologists to abandon the concept or declare it irrelevant, and others to alter it drastically. They say that nature is actually in a continuing state of disturbance and fluctuation. Change and turmoil, more than constancy and balance, is the rule. As a consequence, say many leaders in the field, textbooks will have to be rewritten and strategies of conservation and resource management rethought.

The balance-of-nature concept "makes nice poetry, but it's not such great science," said Dr. Steward T. A. Pickett, a plant ecologist at the Institute of Ecosystem Studies of the New York Botanical Garden at Millbrook, N.Y. He was a co-organizer of a symposium that explored the matter yesterday in Snowbird, Utah, at the annual meeting of the Ecological Society of America, the nation's premier organization of ecological scientists.

While the shift in thinking has not yet produced a coherent new theory to replace the old one, Dr. Pickett characterizes what is going on as "a major revision of one of our basic assumptions of how the natural world works." The developing conviction that nature is ruled more by flux and disturbance is "becoming the dominant idea," he said.

"There will always be people who will cling to old ideas," said Dr. Simon A. Levin, a Cornell University ecologist who is the incoming president of the Ecological Society. "But certainly the center of mass of thinking" among ecologists, he said, has shifted away from equilibrium and toward the fluctuating nature of natural systems.

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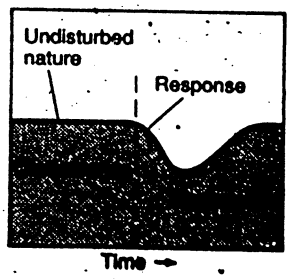
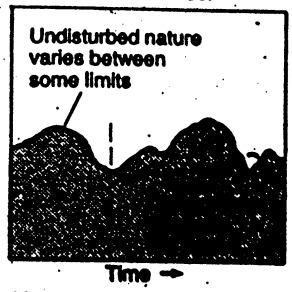
Changing View Of Nature



In the past, ecologists assumed that nature undisturbed was a constant state to which ecosystems and populations of animals would return after disturbances like fires.



Many scientists now believe this model to be incorrect. Populations and ecosystems, they say, always vary within some boundaries and there is no "perfect" state to which their numbers and growth will return if they are disturbed.

Source: Daniel B. Botkin

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Some scientists now say that ecological communities of plants and animals are inherently unstable, largely because of idiosyncratic differences in behavior among communities and individuals in them. A super-aggressive wolfpack leader, for example, can greatly increase the pack's hunting efficiency and destabilize the ecosystem — just as the death of a pack leader can promote instability.

But even if ecological communities do display some sort of internal equilibrium, many scientists believe, external disturbances like climatic change, year-to-year variations in weather patterns, fires, windstorms, hurricanes and disease seldom, if ever, give the communities a chance to settle into a stable state. In this view, the climax forest, the neatly symmetrical predator-prey relationship and the bumper fish population become transient conditions at best, even in the absence of human intervention.

Scientists are finding this to be true on many scales of time and space, from the glacial and global to the seasonal and local, and in parts of the world long considered the most pristine and stable like the tropical rain forests of South and Central America, for instance, or the north woods of Canada and the northern United States.

In the natural landscape, "there is almost no circumstance one can find where something isn't changing the system," said Dr. George L. Jacobson Jr., who, as a paleoecologist at the University of Maine, studies ecological change as it is revealed in ancient sediments and rocks. And while there may be a tendency toward a stable equilibrium, he said, "it's never allowed to get there, so we might as well not expect it to exist."

A Difficulty

Posing a Question: What Is Natural?

In this developing new perspective, humans are emerging as just one of many sources of ecological disturbance that keep nature in a perpetual state of uproar. The question of whether humans should intervene in natural processes is moot, ecologists say, since humans and their near-human ancestors have been doing so for eons, and ecological systems around the world bear their indelible imprint.

The supposedly pristine rain forests of Latin America, for instance, owe some of their character to the intervention of humans who planted and transplanted trees and other plants throughout the jungle. And the supposedly unspoiled Serengeti plain of Africa, some ecologists are convinced, owes its tremendous abundance of grazing animals at least partly to human-set fires that created savanna habitats.

The real question, ecologists say, is which sort of human interventions should be promoted and which opposed.

One of the biggest human interventions, some say, is taking place now as people pour heat-trapping chemicals, mainly carbon dioxide, into the atmosphere. Many climatologists expect that this will cause the Earth's climate to warm significantly, causing especially widespread ecological dislocation.

The temperature of the earth has shifted up and down many times in past eons, ecologists point out, and ecosystems have always adjusted. But this human intervention, scientists say, threatens to force, in a century or less, vast climatic and ecological changes that have usually taken millennia. Ecologists fear that this time, ecosystems will not adjust rapidly enough to stave off catastrophe for many species.

Moreover, some ecologists say, natural disruptions promote diversity of species in a forest, for example, by opening up gaps and patches where different plants can grow than grew before. But they say also that people are eliminating some of this diversity. "We threaten that variability because we want to manage everything like cornfields," said Dr. Julie Denslow, a tropical ecologist at Tulane University. There is, she said, "a whole camp of us" opposed to this "horrible homogenizing."

The new view of nature poses difficulties for conservationists and environmentalists who want to preserve things in their natural condition, scientists say, since the question now becomes: If change is constant, what is the natural state?

What, for instance, is the natural condition of the Adirondacks, where a spirited argument is going on about whether "rough" fish like suckers, shiners and chubs should be killed and removed from some ponds to make way for trout. People on one side of the argument, citing a state policy that aims to "perpetuate natural aquatic ecosystems" in the area, say that the rough fish represent the natural condition and that the ponds should be preserved in that condition. Others say that at least some rough fish are descendants of baitfish brought in by humans and that they have crowded out trout that flourished there earlier.

Is either of these alternative conditions "the" natural state? Or is the natural state the way the Adirondacks were when Europeans first arrived? Or, for that matter, the way they were in the millennia when the region was buried under an ice-age glacier. Or in the succession of different forests, animals and ecosystems that followed?

New View of the Balance of Nature Finds the Real Constant Is Turmoil

"Nature can be in many conditions," said Dr. Daniel B. Botkin, an ecologist at the University of California at Santa Barbara who is a leader of the reassessment effort. Because of that, he said, conservationists and resource managers will be required to analyze a given situation more carefully than in the past and then choose which natural condition to promote rather than simply insist that humans should not upset a supposed balance of nature.

"I think he's right," said Rupert Cutler, the president of the Defenders of Wildlife, a major conservation organization. He said that the shift in thinking "suggests that the responsibility for protecting nature will require a much higher level of intense application of science than it was ever assumed to require in the past."

Empty Theory

Observations Find No Neat Balance

In its classic formulation, the balance-of-nature concept holds that an ecosystem maintains a constant equilibrium and when disturbed, it returns to its former status when the cause of the disturbance is removed.

Many scientists now say it is clear that this is not the way things work.

"We can say that's dead for most people in the scientific community," said Dr. Peter L. Chesson, a theoretical ecologist at Ohio State University who took part in yesterday's symposium along with Dr. Pickett, Dr. Jacobson, Dr. Botkin and Dr. Denslow. The other participants were Dr. Margaret B. Davis, a paleoecologist at the University of Minnesota who helped organize the symposium and Dr. Judy L. Meyer, a stream ecologist at the University of Georgia.

Many observations of the behavior of animal populations in the wild, says Dr. Botkin, do not support the assumption of neat balance predicted by traditional ecological theory. One aspect of the theory says that when a population of animals moves into an area, it grows gradually to a level of abundance at which its environment will allow it to be sustained indefinitely, and then remains at that level. Another says that predator and prey populations in a given ecosystem oscillate in numbers, with one population at a peak while the other is at a low point and vice versa, thereby creating an equilibrium over time.

But in real life, says Dr. Botkin, "when you introduce a population to a new area it goes up and then crashes, and then it doesn't remain constant. The long-term numbers vary and are much lower" than predicted by the theory. Similarly, he said, a number of studies and observations, in the laboratory as well as the wild, show that predator-prey populations do not oscillate stably and predictably. Instead, they either fluctuate wildly and unpredictably or the prey species is eliminated and the predator species dies of starvation. In one famous experiment, paramecium microbes increased rapidly. When predator microbes were introduced, they increased, too. But in the end, the paramecia were exterminated and the predators died of starvation.

Attempts to apply the classical equilibrium principle to the management of marine fisheries led to disaster, according to Dr. Botkin. For years, he said, international regulators of commercial fishing determined allowable annual catches by calculating maximum sustainable yields according to equilibrium theory. The theory was such a poor guide, Dr. Botkin said, that population after population of commercial fish suffered catastrophic declines in the 1950's and 1960's and some have not yet recovered.

Managers of fisheries are trying to move away from that strategy now, he said, by analyzing the more complicated factors that actually determine fish populations. Among these, for example, are the environmental disturbances that largely determine the size of a given year's hatching of young fish. By estimating and keeping track of these varying "year classes," managers hope to adjust catch quotas year-by-year and avoid wiping out an entire class.

Some scientists are not quite ready to abandon entirely the concept of an inherent tendency toward equilibrium in ecosystems. A kind of equilibrium, they say, may exist on some scales of time and space.

Scale, in fact, may be very important. While there may be enormous, unbalancing disturbances and fluctuations among small populations in small ecosystems, says Dr. Pickett, the fluctuations may be dampened when the larger picture is considered, where a sort of medium-scale equilibrium might apply. An animal population that fails in one environment might not do so if allowed to range over a wider area. Dr. Botkin also said it is quite possible that while a given locality's ecology would change markedly over thousands of years, there could be recurring similarities — and thus a kind of floating equilibrium — at medium-range time scales.

That, in fact, is what Dr. Chesson, the theoretician, postulates. There may, for instance, be a limited range in which an animal population fluctuates over several hundred years. An equilibrium could be calculated by taking the average of the fluctuations. But it would be a "real mistake," said Dr. Chesson, to equate this with anything "remotely like" the classical idea of the balance of nature.

Constant Change

Outside Factors Shape Ecosystems

Perhaps the most outstanding evidence favoring an ecology of constant change and disruption over one of static balance comes from studies of naturally occurring external factors that dislocate ecosystems.

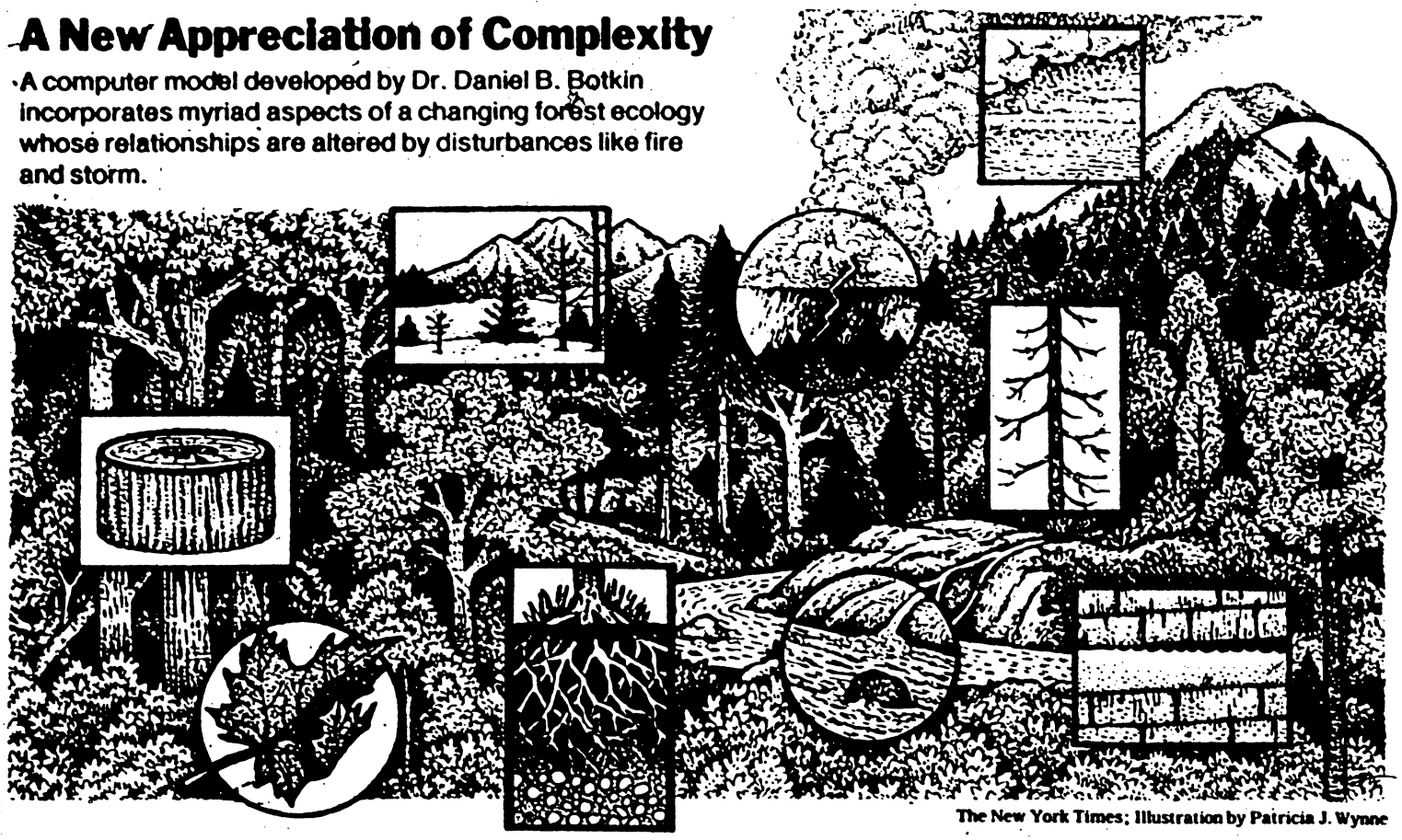
For a long time, says Dr. Meyer of the University of Georgia, these outside influences were insufficiently considered. The emphasis, she said, was "on processes going on within the system," even though "what's happening is driven by what's happened outside." Ecologists, she said, "had blinders on in thinking about external controlling factors."

Climate and weather appear foremost among these factors. By studying the record laid down in ocean and lake sediments, scientists know that climate, in the words of Dr. Davis of the University of Minnesota, has been "wildly fluctuating" over the last two million years, and the shape of ecosystems with it. The fluctuations take place not only from eon to eon, but also from year to year and at every scale in between. "So you can't visualize a time in equilibrium," said Dr. Davis.

Dr. Jacobson said there is virtually no time when the overall environment stays constant for very long. "That means that the configuration of the ecosystems is always changing."

A New Appreciation of Complexity

A computer model developed by Dr. Daniel B. Botkin incorporates myriad aspects of a changing forest ecology whose relationships are altered by disturbances like fire and storm.



The New York Times; Illustration by Patricia J. Wynne

Diameters of tree trunks; characteristics of each species.

Leaves of every tree to calculate shade produced.

Composition, depth, and nitrogen content of soil.

How much water is stored by vegetation, evaporates, or runs off.

Water table; how much snow melts.

Mortality data for each tree species.

Latitude, temperature and rainfall data.